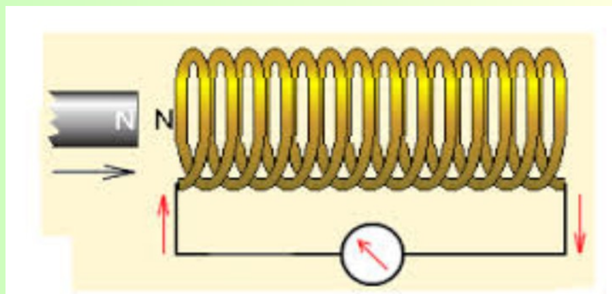
Magnetic fields	**Electromagnetic induction**

Learning objectives	**MUST (C)**	Explain what is meant by electromagnetic induction, and what affects its magnitude & direction
	SHOULD (B)	Define magnetic flux, magnetic flux density and magnetic flux linkage
	COULD (A/A*)	Calculate magnetic flux in given situations

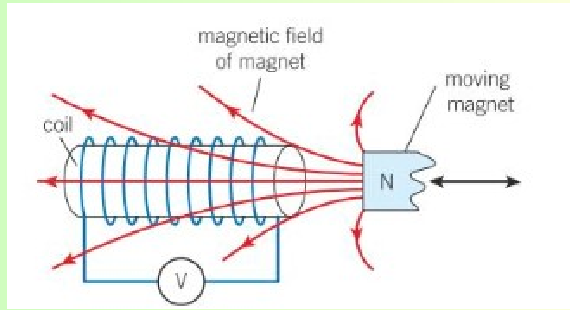
STARTER: Recall your GCSE studies. When you moved the magnet in and out of the coil, what affected the size/ direction of the galvanometer reading?



EXTENSION: Can you think of any practical uses for this effect?

Magnetic fields	**Electromagnetic induction**
MUST (C)	Explain what is meant by electromagnetic induction, and what affects its magnitude & direction

Electromagnet induction occurs when a conductor and magnetic field move relative to each other. An emf is induced across the ends of the conductors. One example is the magnet pushed in the coil: if the magnet is pulled out, the reverse emf is induced, and the emf is greater when the magnet is moved faster.



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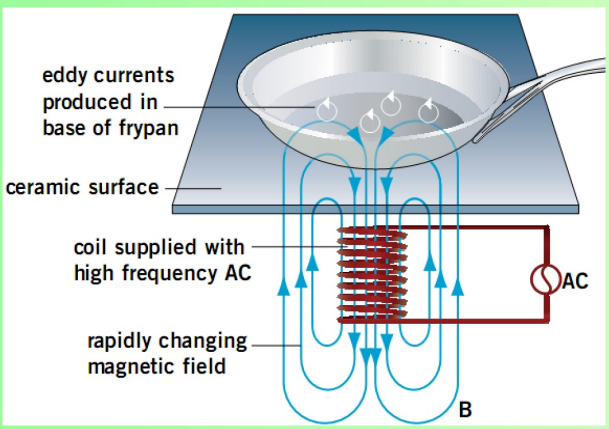


Induction hobs, such as the ones below, heat food without using gas or conventional electric heating. How do they work? Why are they safe and efficient? Any drawbacks?

Magnetic fields	**Electromagnetic induction**
SHOULD (7)	Define magnetic flux, magnetic flux density and magnetic flux linkage
COULD (8/9)	Calculate magnetic flux in given situations

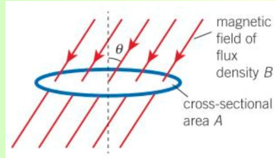
An emf is induced when there is a *change* in the magnetic flux linking the circuit. You need to be able to distinguish between **magnetic flux** and **magnetic flux density.**

Quantity	Definition	Unit
Magnetic flux density, B	The strength of a magnetic field, defined by B = F/IL	T
Magnetic flux, Φ	The product of the component of the magnetic flux density perpendicular to a given area and that cross-sectional area	Wb

$\Phi = (B\cos\theta)\,A$

When the field is normal to the area....

$\Phi = BA$



▲ **Figure 5** *Magnetic flux ϕ is the product of the component of the magnetic flux density perpendicular to the area and the cross-sectional area*

<u>Magnetic flux linkage</u>

magnetic flux linkage = number of turns on a coil x magnetic flux

magnetic flux linkage = $N\Phi$

magnetic flux linkage = $BAN\cos\theta$

A coil has 200 turns and a core of cross-sectional area $1.0 \times 10^{-4}\,m^2$. The coil is placed at right angles to a magnetic field of flux density 0.30 T. Calculate the magnetic flux and magnetic flux linkage for the coil.

Step 1: Calculate the magnetic flux. At right angles, magnetic flux $\phi = BA = 0.30 \times 1.0 \times 10^{-4} = 3.0 \times 10^{-5}$ Wb

Step 2: The magnetic flux linkage is $N\phi$. Therefore Magnetic flux linkage $= N\phi = 200 \times 3.0 \times 10^{-5} = 6.0 \times 10^{-3}$ Wb

Now try summary questions 3-6 in section 23.4

3 $\phi = BA\cos\theta = 0.02 \times 1.4 \times 10^{-4} \times \cos 0°$ [1]
$\phi = 2.8 \times 10^{-6} \approx 3 \times 10^{-6}$ Wb [1]

4 $\phi = BA\cos\theta = 0.20 \times [\pi \times 0.014^2] \times \cos 30°$ [1]
$\phi = 1.07 \times 10^{-4}$ Wb
$N\phi = 400 \times 1.07 \times 10^{-4} \approx 4.3 \times 10^{-2}$ Wb turns [1]

5 B is a vector quantity, hence the change in the flux density is 0.40 T. [1]
change in flux $= 2 \times 1.07 \times 10^{-4}$ Wb
change in flux linkage $= 400 \times 2 \times 1.07 \times 10^{-4} \approx 8.6 \times 10^{-2}$ Wb turns [1]

6 radius of coin ≈ 1.0 cm; $A = \pi \times 0.01^2$ (allow ± 30%) [1]
$\phi = BA\cos\theta = 4.9 \times 10^{-5} \times [\pi \times 0.01^2] \times \cos 24°$ [1]
$\phi = 1.41 \times 10^{-8}$ Wb $\approx 1.4 \times 10^{-8}$ Wb [1]

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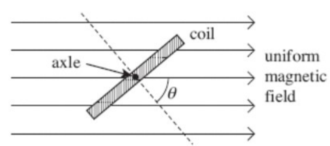
PLENARY:



A coil of 50 turns has a cross-sectional area of 4.2×10^{-3} m^2. It is placed at an angle to a uniform magnetic field of flux density 2.8×10^{-2} T, as shown in the diagram, so that angle $\theta = 50°$.

What is the change in flux linkage when the coil is rotated anticlockwise until $\theta = 0°$?

A The flux linkage decreases by 2.1×10^{-3} Wb turns.

B The flux linkage increases by 2.1×10^{-3} Wb turns.

C The flux linkage decreases by 3.8×10^{-3} Wb turns.

D The flux linkage increases by 3.8×10^{-3} Wb turns.

(Total 1 mark)

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